

Forbo Linoleum

Product Selection and Description

Linoleum is a resilient, organic-based floor covering consisting of a backing covered with a thick wearing surface. Oxidized linseed oil and rosin are mixed with the other natural ingredients to form linoleum granules. These granules are then calendared onto a jute backing, making a continuous long sheet. The sheets are hung in drying rooms to allow the naturally occurring process to continue until the product reaches the required flexibility and resilience. The sheets are then removed from the drying rooms, cut into rolls, and prepared for shipment.

Forbo Marmoleum may be installed using either a styrene-butadiene or a no-VOC adhesive. Both installation options are included in BEES.

Flow Diagram

The flow diagram below shows the major elements of the production of this product as it is currently modeled for BEES.

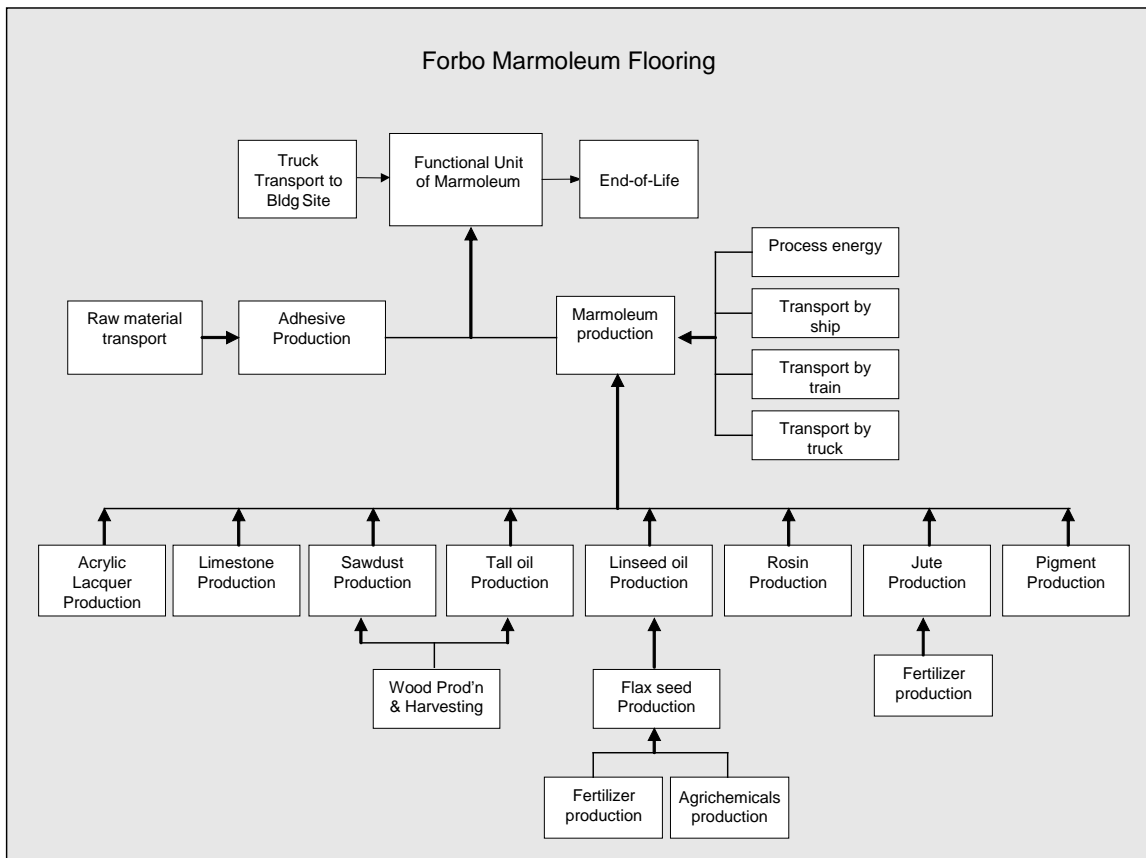


Figure 1: Forbo Marmoleum System Boundaries

Raw Materials

The Table below lists the constituents of 2.5 mm (0.10 in) linoleum and their proportions.

Table 1: Forbo Marmoleum Constituents

<i>Constituent</i>	<i>Mass Fraction¹</i>	<i>Mass per Applied Area in g/m² (lb/ft²)</i>
Linseed oil	20 %	588 (0.12)
Tall oil	13 %	398 (0.08)
Pine rosin	3 %	76 (0.02)
Limestone	20 %	592 (0.12)
Wood flour	31 %	901 (0.18)
Pigment	4 %	101 (0.02)
Jute (backing)	8 %	233 (0.05)
Acrylic lacquer	1 %	12 (0.00)
Total:	100 %	2 901 (0.59)

For lack of other available data, the cultivation of linseed is based on a modified version of wheat production from the U.S. LCI Database. To harvest the linseed, it is assumed that a diesel tractor is used – approximately 0.61 MJ (0.17 kWh) of diesel is consumed per kg (263 Btu/lb) of linseed harvested. The yield for linseed is 1 038 kg per hectare (420 lb per acre). Energy requirements for linseed oil production include fuel oil and steam, and are allocated on an economic basis between linseed oil (87 %) and linseed cake (13 %). Allocation is necessary because linseed cake is a co-product of linseed oil production, so its production impacts should not be included in the BEES model. The emissions associated with linseed oil production are allocated on the same economic basis. The production of the fertilizers and pesticides is based on elements of the SimaPro and EcoInvent databases.

The production of tall oil is based on European data for kraft pulping, with inventory flows allocated between kraft pulp and its coproduct, tall oil.² Pine rosin production is assumed to have no burdens, since the harvesting of raw pine rosin is done mainly by hand, according to Forbo.

The production of limestone comes from the U.S. LCI Database. Wood flour is sawdust produced as a coproduct of wood processing, and its production is based on the U.S. LCI Database.

Data for production of the pigments used in the product is modeled based on the European production of titanium dioxide, and comes from EcoInvent. Linoleum backing, jute, is mostly grown in India, Bangladesh, Thailand, and China. Jute is a predominantly rain-fed and requires little fertilizer and pesticides, and cultivation is generally manual. Jute data are based on an EcoInvent dataset for rain-fed jute fiber production in India. Data for the production of acrylic lacquer materials come from EcoInvent data on an acrylic binder.

Manufacturing

Energy Requirements and Emissions. The production of each unit of Marmoleum (0.09 m² or 1 ft²) requires 0.45 MJ (0.13 kWh) of electricity and 1.8 MJ (0.5 kWh) of natural gas. Burdens from the production and use of energy are based on the U.S. LCI Database.

Transportation. Transportation distances for shipment of the raw materials from the suppliers to the manufacturing plant in Europe are provided by Forbo. In addition to raw materials transport, the manufacturing life-cycle stage includes transport of the finished product from the European manufacturing plant to the United States. All of these requirements, involving transport by diesel truck, rail, and ocean freighter, are accounted

¹ Marieke Goree, Jeroen Guinée, Gjalt Huppés, Laurant van Oers (The Netherlands: Leiden University, 2000).

² Fédération Européenne des Fabricants de Carton Ondulé (FEFCO), 2003. Found at: http://www.fefco.org/fileadmin/Fefco/pdfs/Technical_PDF/Corrected_database_2003.pdf.

for, with data based on the U.S. LCI Database.

Transportation

Transportation by diesel truck of the finished product from the U.S. distribution facility to the building site is modeled as a variable in BEES.

Installation

Marmoleum may be installed using 0.0003 kg (0.0007 lb) of either a styrene-butadiene or a no-VOC adhesive. Additionally, an acrylic sealant is applied to the flooring at each installation. Approximately 6 % of the flooring is wasted and landfilled at installation.

Use

Linoleum is known for its durability. Through evaluation of actual lifetime data, it has been determined that linoleum has a useful life of 30 years.³ As with all BEES products, the life cycle environmental burdens from replacement are included in the inventory data.

End of Life

At the end of its life, the used flooring is sent to a landfill.

References

Life Cycle Data

National Renewable Energy Laboratory (NREL): *U.S. Life-Cycle Inventory Database*. 2005. Golden, CO.

Found at: <http://www.nrel.gov/lci/database>.

PRé Consultants: *SimaPro 6.0 LCA Software*. 2005. The Netherlands.

EcoInvent Centre, *EcoInvent data v2.0* (Dübendorf: Swiss Centre for Life Cycle Inventories, 2007). Found at: www.ecoinvent.org.

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http://www.fefco.org/fileadmin/Fefco/pdfs/Technical_PDF/Corrected_database_2003.pdf

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Industry Contacts

Tim Cole, Forbo Industries (2002)

³ Federal Association of the Sworn Experts for Room and Equipment e.V., *Guide to the Inquiry of Time Values and Decreases in Value of Floor Coverings*(Bonn, Germany: Federal Association of the Sworn Experts for Room and Equipment e.V.).